Towards recognition of seagrasses, and their sustainable management

Authors: Mike van Keulen[1,2*], Lina Mtwana Nordlund[3], Leanne C Cullen-Unsworth[4]

[1] Centre for Sustainable Aquatic Ecosystems, Harry Butler Institute, Murdoch University, Murdoch, WA 6150, Australia

[2] School of Veterinary & Life Sciences, Murdoch University, Murdoch, WA 6150, Australia

[3] Department of Ecology, Environment and Plant Sciences, Stockholm University, SE-106 91 Stockholm, Sweden

[4] Sustainable Places Research Institute, Cardiff University, 33 Park Place, Cardiff, CF10 3BA, UK

*Corresponding author: M.Keulen@murdoch.edu.au

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Seagrass meadows: an underappreciated global resource

Seagrasses are marine flowering plants that form extensive meadows in coastal seas around the world (Plate 1). Seagrasses are unquestionably valuable to humans and play a multifunctional role in human-wellbeing, both directly and indirectly (Cullen-Unsworth et al., 2014; Nordlund et al., 2016). However they are being lost at rapid rates around the globe (Waycott et al., 2009), with loss commonly associated with coastal development, poor land management, and fisheries overexploitation. Marine conservation priorities do not recognise the value of the goods and services that seagrasses provide, despite growing evidence of their importance. In general, biodiversity and conservation measures give only secondary consideration to seagrass (Nordlund et al., 2017a; Unsworth et al., 2010).

[Insert Plate 1]

Plate 1. Mixed species seagrass meadow in Bali, Indonesia.

To draw attention to the plight of seagrass meadows, in 2016, the World Seagrass Association (WSA) released a statement (http://wsa.seagrassonline.org/securing-a-future-for-seagrass/) that has been endorsed by 140 scientists across 35 countries, calling on all governments and global institutions to take local, regional and global action to ensure the future survival of seagrass meadows. The letter highlights the global importance of seagrass meadows, outlining changes that have been observed within these systems in the past century, specifying and predicting the most significant current and future threats. However, the letter also outlined some reasons to be optimistic, recognising that some significant positive changes are taking place. Monitoring is improving, we have increasing evidence of successful seagrass restoration, and our knowledge of the ecology of seagrasses is growing. But progress is slow and existing efforts provide just the starting blocks from which stakeholders, including scientists, conservationists, policy makers and managers worldwide need to target strategic action towards achieving a brighter future for seagrass.

We need to act urgently if we want to continue to enjoy the services that seagrasses provide. Improved knowledge that can provide a platform for conservation action is required and here we outline some current effort toward this aim. We discuss four major themes that we believe are emerging as key banners for contemporary scientific research on seagrasses:

- Seagrass ecosystem services

- Resilience and a changing environment
- Management and Restoration
- Raising the profile of seagrass meadows

In setting up this special issue, we sought a diversity of papers that would further address the themes outlined above, presenting contemporary research across the spectrum of seagrass research, and including experimental evidence, reviews and opinion pieces.

Seagrass ecosystem services

Seagrasses provide a wide range of ecosystem services that support human wellbeing. These include the provision of rich fishing grounds(Nordlund et al., 2017b), other fisheries support, coastal protection of sandy shores (Paul, 2017) and carbon sequestration (Mazarrasa et al., 2018) amongst others. Research effort and associated evidence is growing of the value of the ecosystem services provided by seagrass meadows. Three key areas to advance seagrass ecosystem service research have been identified by Nordlund et al. (2017a). These areas are 1) Variability of ecosystem services within seagrass meadows and among different meadows; 2) Seagrass ecosystem services in relation to, and their connection with, other coastal habitats; and 3) Improvement in the communication of seagrass ecosystem services to the public. We need to investigate which messages are most effective to communicate, how to reach broader levels of society, and the mechanisms by which to communicate.

For more accurate valuation of the ecosystem services that seagrasses provide we also need improved estimates of local, regional and global scale seagrass cover. There is considerable uncertainty in how much seagrass there is around the world, the relative proportions of seagrass species in different ecosystems, and how ecosystem services are provided by different species. Current estimates of global seagrass cover vary between around 177 000 – 600 000 km^2 (Mcleod et al., 2011; Waycott et al., 2009). A sparsity of data is problematic but emerging methods and technologies are leading to improved estimates of seagrass cover and composition in some regions (Traganos and Reinartz, 2017).

Resilience and a changing environment

Despite low floral diversity, seagrass meadows support a high diversity of faunal taxa, including commercially important food fishes (e.g. snapper, rabbitfish) and charismatic, cultural keystone species such as turtle, dugong, seahorse and sea otters (Hessing-Lewis et al., 2017). Protecting seagrasses as foundation species will protect species richness, biodiversity, ecosystem structure, fisheries support function, climate regulation through carbon sequestration and other essential ecosystem services.

In a rapidly changing environment, seagrass has shown signs of resilience (e.g. Egea et al. (2018)), but their resilience is compromised by a range of local to global stressors, resulting in ecological regime shifts that could undermine the long-term viability of these productive ecosystems (e.g. Gamain et al. (2017); Lin et al. (2018); O'Brien et al. (2017); Sullivan et al. (2017); Unsworth et al. (2015)).

Management and restoration

While new approaches to management of our coastlines help provide a future for seagrass ecosystems, we still do not have a comprehensive audit of seagrasses globally. Previously unknown meadows are still being discovered (Esteban et al., 2018), and novel approaches are required to monitor their status (e.g. Traganos and Reinartz (2017)), Improved data on the abundance and distribution of seagrass meadows globally is required, as well as a better understanding of the risks they face, in order to develop strategic plans for protected areas that include significant expanses of seagrass and that aim to strengthen management and sustainable use of natural resources, while protecting connected ecosystems. While working under united regional and international frameworks, seagrass management should be context-specific, taking into account local use patterns and actively engaging stakeholders (Cullen-Unsworth et al., 2014; Cullen-Unsworth et al., 2016). Co-production and communication of knowledge are essential for localised seagrass protection, and there is significant untapped information and support available in local ecological knowledge(Cullen-Unsworth et al., 2017).

For some specific ecosystem services, for example fisheries support, exploitation patterns and fish movements support the need for an Ecosystem Approach to resource management covering the range of representative habitats, particularly seagrass meadows (Nordlund et al., 2017b; Unsworth et al., 2010). Further understanding of all habitats important to local

fisheries will enable optimal siting of marine protected areas, for example, to maximise food security and biodiversity conservation benefits. We need to mobilise an Ecosystem Approach integrating ecological, social and economic disciplines and create a cooperative research environment to bridge gaps between research, policy development, management and local communities (Cullen-Unsworth et al., 2016).

While new approaches to management of our coastlines help provide a future for seagrass ecosystems, the scale of seagrass losses in some areas means that natural recovery is unlikely, or very slow. In these instances, restoration programs have been established, using a variety of techniques to replace or enhance seagrass recovery, although the need to first resolve the underlying causes of the seagrass loss is often overlooked (Paling et al., 2009). Any effort to restore a degraded ecosystem must first start by identifying the underlying problems, before endeavouring to resolve those problems and restore the damaged ecosystem. This requires comprehensive review of environmental impacts and local considerations, and an understanding of the management landscape (Lefcheck et al., 2018). Actual restoration research, while having made many significant advances over recent decades, is complex and multidisciplinary, requiring an understanding of the many factors interacting to support seagrass growth. The complexity of this topic dictates a combination of laboratory studies and real-world experiments (e.g. Gu et al. (2017); Pereda-Briones et al. (2017)). While seagrass restoration has been a topic of research for several decades, the mixed success of restoration projects, and changing environmental conditions, show that there is still much to learn.

Raising the profile of seagrass meadows

Seagrass research has for too long lagged behind both coral reef and mangrove research in achieving public recognition, but seagrass research may now be turning a corner in terms of how it is perceived, with signs of it entering the scientific as well as media mainstream (Hind-Ozan and Jones, 2017). The World Seagrass Association's (WSA) series of biennial International Seagrass Biology Workshops (ISBW) have played a pivotal role in highlighting the importance and plight of seagrass ecosystems globally (Coles et al., 2014). The ISBW is increasingly used as a platform not only to discuss the latest advances in seagrass science and develop strategic cross disciplinary strategies, but also to raise wider awareness of the

importance of seagrass systems as a global resource. The 12th ISBW in 2016 continued that trend, with an increasing focus on social media and a corresponding peak in seagrass media attention online (Duarte, 2016; Hind-Ozan and Jones, 2017). ISBW12 adopted the theme of "Securing a future for seagrass", in line with rationale from the 'Ocean Optimism' movement (see http://www.oceanoptimism.org/) in the belief that positive action and stories can encourage more positive will (Bertelli et al., 2017). More people talking about the value of seagrass, including poignantly the potential role of seagrass in climate change mitigation (Macreadie et al., 2017; Mazarrasa et al., 2018) and food provision (Nordlund et al., 2017b; Unsworth et al., 2014) can only be a good thing for its survival prospects.

Growing recognition of the extensive ecosystem services provided by seagrasses, and the way in which these are being eroded, is being more effectively translated for the public, through improved science communication. Public frustration at perceived government inaction and policy ineffectiveness is helping drive greater involvement in citizen science activities, which both add to the monitoring effort and also further increase public awareness. The success of monitoring programs like Seagrass Watch/SeagrassNet, and the SeagrassSpotter phone application (Jones et al., 2017) are signs of increasing public awareness and interest in the health of seagrass ecosystems.

Conclusion

We live in a rapidly changing world: the effects of local-scale human impacts and global climate change are undeniable and are affecting our marine ecosystems in a wide variety of ways both directly and indirectly. Ecosystem-level changes have included disease, physiological stress, and distributional changes. As such, current seagrass science focuses significantly on resilience, reflected by this special issue in which aspects of seagrass resilience and seagrass responses to a changing environment are highlighted.

Seagrass ecosystems are subject to a suite of impacts that threaten the wide range of ecosystem services that seagrasses provide, including coastal protection, and feedback loops for future climate change, such as carbon sequestration. Our improved understanding of the way in which seagrass ecosystems function, the services they provide, and the way they respond to stressors means that we have stronger arguments in support of their protection and appropriate management.

Seagrass decline can be largely linked to human impacts, which is due primarily to the proximity and accessibility of seagrasses to humans. Seagrasses are important in maintaining ecosystem services, of value to humans and indirectly through their value to other organisms and the physical environment. While our understanding of the role of seagrasses has steadily improved over the last several decades, the general public and managers have been largely unaware of the importance of seagrass ecosystems. One of the major challenges we face in conserving seagrass ecosystems, and protecting the ecosystem services they provide, is lack of public awareness. But this is changing. It is increasingly clear that seagrasses are playing, and will continue to play, an important role in supporting our coastal ecosystems; encouragingly, this message is starting to permeate into management and the general public. We have seen some exciting developments in increased protection for seagrass ecosystems, and new directions for research into seagrass habitat restoration. Such improved awareness will be critical in maintaining seagrass ecosystems, so that they in turn can help protect our coastal environments as we face continued pressure from climate change.

In recent years, we have seen increasing multidisciplinary seagrass research. Even so, there are still many knowledge gaps about seagrass that need to be filled, including basic ecological and distributional knowledge. We argue that more research involving researchers from multiple disciplines is needed, as well as a transdisciplinary approach, with policy makers and other stakeholders, to achieve action for securing a future for seagrass. We encourage researchers from different fields to include seagrass in their studies; for example evolutionary and molecular biologists, anthropologists, science communicators, and social scientists in general. We also encourage the world's budding citizen scientists to get involved and help monitor this precious resource.

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